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TEXAS AGRICULTURAL EXPERIMENT STATION

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

W. B. BIZZELL, President

BULLETIN NO. 243 MARCH, 1919

DIVISION OF CHEMISTRY

THE NEED OF TEXAS SOILS FOR LIME

B. YOUNGBLOOD, Director

COLLEGE STATION, BRAZOS COUNTY, TEXAS

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†As of March 1, 1919.
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Bulletin No. 243 March, 1919

THE NEEDS OF TEXAS SOILS FOR LIME

BY

G. S. FRAPS, PH. D., CHIEF, DIVISION OF CHEMISTRY; STATE CHEMIST.

The requirements for the maintenance of the fertility of Texas soils have been discussed in previous bulletins of this Station. The more important requirements consist in maintenance of the vegetable matter and nitrogen content of the soil by means of proper legume rotation, the use of nitrogenous fertilizers, and the use of phosphates. The potash requirements of the soil, and needs of the soil for lime are to be considered among the less important requirements of the state as a whole, though for some crops and for some localities they may be very important. The object of this bulletin is to discuss the needs of Texas soils for lime, as far as our present information permits.

WHAT LIME DOES

Lime performs several functions in the soil, some of which are favorable to increased crops and the maintenance of fertility, some favorable to certain crops, and some unfavorable to the maintenance of fertility on certain soils.

Lime as a plant food. Lime is not classed as a fertilizer, though plants need lime in order to grow. It is generally believed that soils contain enough lime to supply all the needs of the plants, which are not large, as a rule.

However, there are some classes of plants which need fair amounts of lime. These especially include alfalfa and clover. Some soils may possibly not supply enough lime for the best development of these plants. In the light of our present knowledge, lime cannot be regarded as a fertilizer or plant food.

Lime affects the physical character of the soil. Clay soils, which are sticky and difficult to work and which do not contain much lime, are often improved in physical character by additions of lime. They become more friable, more easily cultivated, and more easily penetrated by water. They do not harden so readily after a rain, and in general become easily cultivated. Soils which are hard for three horses to plow sometimes are easily plowed by two horses, after proper liming.

A soil which, when plowed, breaks up into a mass of compound particles of various sizes, loosely piled upon one another and separated by comparatively large interspaces, is said to possess the crumb structure and to be in good tilth. The crumbs may be held together by moisture, clay, humates, and carbonates of lime, and sometimes silica and oxide of iron. A sticky clay poor in lime produces little crumb structure, but the proper addition of lime will cause the formation of crumbs and aid decidedly in promoting good tilth.

Lime, added to a sticky clay soil and even to some loams, aids in the retention of water, and this is a decided advantage under Texas conditions. The lime makes the soil more porous and permits the rain to penetrate it more easily. On some soils the rain causes the formation of a crust and flows off without penetrating as much as it should. Lime added to such soils produces a more porous and open structure. The soil also produces a better mulch under cultivation. Thus, the cultivation is more effective in preventing loss by evaporation. Bulletins No. 171 and 183 of this Station contain experimental evidence along this line.

Lime may make phosphoric acid more available. Addition of lime to soils which need it may make some of the plant food more available to plants. Bulletin No. 178 of this Station shows that the addition of lime increased the phosphoric acid withdrawn from the soil in pot experiments. With six soils that naturally give up phosphoric acid in the pot experiments sufficient for the production of from five to eight bushels of corn per acre, the addition of carbonate of lime caused an increase in the phosphoric acid taken up equal to from three to seven bushels per acre. It is probable that lime acts by changing less available phosphates of iron and aluminum to the somewhat more available phosphate of lime. It would also decrease the production of iron and aluminum phosphate from phosphate added to the soil.

The use of lime to render soil phosphate more available would be of only temporary advantage in the case of soils now in total phosphoric acid, since the lime would aid in the more rapid exhaustion of the soil phosphates, and, consequently, the more rapid impoverishment of the soil.

Lime and potash. Lime is claimed by some to make potash more available, but pot experiments at this Station (Bulletin No. 190) show that the active potash is so highly available that the lime has no effect upon it.

Lime and nitrogen. Lime aids in changing the nitrogen of the soil into forms easily taken up by the plant. This action of lime is sometimes desirable, but in other cases it is highly undesirable, as it merely results in the more rapid impoverishment of the soil in nitrogen.

The addition of lime to the soil increases the production of nitrates. The nitrates are highly soluble and easily washed out of the soil. Unless they are taken up by the plant, they are likely to be washed out and lost. Further, this action continues after the crop is removed from the soil. In northern climates the ground is cold and often frozen during the winter seasons, and this checks the action of the bacteria which produce nitrates, and decreases the percolation of water through the soil. In more southern climates the soil is warmer and more open, nitrification goes on and nitrates are formed, and the winter rains wash them out of the soil. The addition of lime to a soil results in much greater loss of nitrogen in the south than in the north, due to climatic conditions. It also appears from some of our work that more nitrates may be produced through the use of lime without causing a greater production of crop or a greater quantity of nitrogen to be taken up by the crop. That is to say, the lime may increase the soluble nitrates, which are easily lost, without increasing the available nitrogen suitable for the growth of the plant. The improper use of lime in southern soils is likely to lead to impoverishment of the soil in nitrogen, and this fact in itself is enough to make one hesitate to recommend the use of lime on any soil in the south until one can be satisfied that the advantages of the application will outweigh the disadvantages.

Lime and alkali. Lime added to soils containing nitrate of soda or other alkalies is liable to change part of the alkali into carbonates, which are much more injurious to plants than the original alkali.

$$Na_2SO_4+CaCO_3=CaSO_4+Na_2CO_3.$$
$$Na_2SO_4+Ca(OH)_2=NaOH+CaSO_4.$$
$$2\ NaOH+CO_2=Na_2CO_3+H_2O.$$

Alkali carbonates are also injurious to the soil, as they cause it to puddle and run together. Hydrated lime or stone lime would be more injurious than the carbonate of lime, since it would probably form caustic soda at first. Lime should not be used upon alkali soils, as a rule.

ACIDITY OF SOILS

Lime is used to correct the acidity of soils. Some soils are acid, and the acidity is injurious to some crops. Other crops do better in an acid soil than in an alkaline soil, but for most crops an alkaline condition is more favorable. Soils of the north appear to be acid more frequently and to a greater extent than the soils of the south.

Cause of acidity. The acidity of the soil is due to several different causes, and there is no doubt that the effect on some plants must be different for these different things. Some of the causes of acidity are as follows:

(A) The presence of free sulphuric acid, due to the use of sulphate of ammonia on soils containing insufficient lime to neutralize the acid, or, more rarely, oxidation of free sulphur in the soil.

(B) The presence of acid organic compounds, formed from decaying vegetable matter, especially in swamps or places which remain wet.

(C) The presence of sulphates or chlorides of iron or aluminum in the soil. These may be originally present, or sulphates may be formed by the action of ammonium sulphate on the soil, or by the oxidation of iron pyrites.

(D) The presence of compounds in the soil which react with chlorides, nitrates, sulphates, or similar salts, to form soluble iron and aluminum salts, and perhaps free acid also.

(E) The presence of organic or inorganic compounds which neutralize or absorb lime. These may or may not be acid, or may have a very low degree of acidity. An example is the high absorptive power of certain varieties of kaolin for lime.

These substances which cause acidity may vary quite differently in their effect upon plants. It is probable that the soluble salts of iron and aluminum are quite toxic. Free sulphuric acid also probably has a high degree of toxicity. Acid organic compounds would perhaps vary from a low to a high degree of toxicity, depending upon the nature of the compounds present and their relative proportions. Compounds which merely absorb lime are probably of a low degree of harmfulness to plants. Thus the effects of acidity upon the same plant in different soils will depend upon the cause of the acidity. Different plants also vary in their behavior to acidity, as is seen below.

Relation of plants to acidity. The relation of various plants to acidity has been studied most largely at the Rhode Island Station, on a soil originally acid but with the acidity increased by the use of ammonium sulphate as a fertilizer, or diminished or counteracted by liming or by the use of nitrate of soda. The acidity in this Rhode Island soil is probably of a high degree of toxicity.

The following gives the ascertained effect of lime on various crops as found by the Rhode Island Experiment Station:

Benefited by lime—Alfalfa, asparagus, barley, beets, clover, celery, cauliflower, currants, cabbage, cucumbers, corn, lettuce, mangelwurzel, onions, okra, oats, peas, peanuts, pepper, parsnip, pumpkin, sorghum, salsify, seed fruits, stone fruits, squash, sugar beets, salt bush, timothy and tobacco.

Indifferent to lime—Blackberry, millet, potatoes, raspberries, rye, and red top grass.

Injured by lime—Cranberries, cowpeas, sheep sorrel, lupine, serradella, and watermelon. Liming Irish potatoes renders them liable to scab.

Phosphoric acid and acidity. It has been claimed that soils low in phosphoric acid are generally acid. This is not the case in Texas but will be discussed in another bulletin.

SOURCES OF LIME

Lime may be applied to the soil in several different forms. There is often a decided difference in the cost of the applications in the different forms. The most important forms found in Texas are stone lime, hydrated lime, limestone screenings, ground limestone rocks, ground oyster shells and marl deposits. Fifty-six pounds of fresh pulverized quicklime are equal to seventy-four pounds dry water-slacked lime or hydrated lime, and one hundred pounds pure limestone or shells or dry air-slacked lime. Some analyses of these forms of lime materials are given in table 1.

Table 1.—Analyses of materials carrying lime.

Lab. No.		Lime	Magnesia	Potash	Phosphoric acid	Iron and Alumina	Insoluble
1000	Green sand	1.95	3.46	......	.11	25.72	......
4937	Green sand	......	......	0.25	0.29	......	......
1958	Green sand marl	.72	1.11	.51	.012	40.70	45.06
2088	Green sand marl	1.04	1.57	.45	.56	38.42	34.67
9767	Marl	38.14	1.00	......	.32	7.26	18.22
11486	Shell marl	25.44	2.68	......	.29	......	26.09
11507	Green sand marl	.09	.68	.43	0.10	29.60	54.82
12411	Shell marl	10.04	1.19	......	.07	......	55.25
6057	Rock	19.20	.80	.13	.08	2.19	59.01
8262	Limestone rock	49.15	.54	.06	......	1.04	5.44
8004	Crushed limestone	45.06	.57	......	.11	......	13.66
10676	Crushed limestone	49.24	.64	......	0.147	1.76	8.09
14206	Limestone rock	43.05	6.24	......	......	......	2.55
12628	Limestone	51.75	.38	......	......	......	4.10
14578	Limestone rock	54.82	.28	......	......	......	0.80
14583	Limestone rock	55.31	0.36	......	0.02	......	0.80
11411	Fossiliferous limestone	......	......	......	......	.07	89.50
11412	Fossiliferous limestone	9.60	.68	......	0.11	1.32	78.90
5714	Shell shale	45.95	.17	.04	.06	3.00	12.05
5715	Small shell	48.84	.28	.68	.05	3.35	4.79
5716	Large shells	51.30	0.22	.44	.05	2.05	2.00
5718	Oyster shells	49.74	.39	.00	.05	3.43	3.38
8299	Oyster shell meal	50.20	.89	......	.11	......	3.54
8810	Clam shell	54.82	.26	......	......	......	.37
5492	Shell rocks	25,76	.47	.88	0.20	......	37.54
5493	Shell rocks	23.16	.34	.47	0.20	......	42.68
9528	Oyster shell dust	50.00	.44	......	.11	......	5.19
9770	Shell rock	54.50	.45	......	.05	......	.90
10886	Shell rock	47.60	.55	......	0.13	2.28	13.73
2185	Ashes (weeds)	21.02	......	3.02	1.04	......	......
5914	Hardwood ashes	30.10	0.95	2.70	.90	......	......
7337	Ashes	......	......	4.24	4.80	......	......
9195	Rice straw ashes	2.73	1.61	6.38	.78	......	68.50
9410	Lignite ashes	......	......	.20	.05	......	......
9563	Mesquite ashes	30.41	16.44	4.65	1.28	......	7.69
9758	Pine ashes (leached) 47 per cent water	11.97	3.39	.21	0.93	......	16.92
9775	Peanut hull ashes	8.98	3.30	3.18	4.67	......	65.57
9776	Mesquite wood ashes	39.26	.71	6.35	......	......	6.90
11227	Ashes of cactus	......	......	22.95	......	......	......
11272	Pine wood ashes	......	......	1.10	2.12	......	......
11273	Rice straw ashes	......	......	.28	0.81	......	......
11413	Pine ashes (not exposed) 16.7 per cent water	25.32	8.75	5.73	1.12	......	11.24
11414	Pine ashes exposed to weather, 29.3 per cent water	21.77	7.05	.06	0.90	......	9.40
11429	Peanut hull ashes	8.09	3.60	10.20	2.50	......	29.83
13809	Ashes from mesquite wood	......	......	3.37	.52	......	......
13810	Ashes from Tepary bean hay	......	......	2.38	1.05	......	......

Stone lime. Stone lime is prepared by burning limestone, and is used for building purposes. It is highly effective for neutralizing acidity, but as a general rule it is too expensive in Texas to use for agricultural purposes, excepting when only a few hundred pounds are needed for some special purpose. Stone lime should be slacked before it is applied. This is often done by piling it on the land, covering with earth, and then spreading it when slacked.

Hydrated lime. Hydrated lime is prepared by slacking lime with steam or water so that it falls to a powder. It contains less lime than stone lime, on account of the water added. It is easily applied, but it is too expensive to apply to soils in Texas, unless needed for some special purpose.

Limestone screenings. In the manufacture of stone lime for building purposes, there is always a quantity of rock too small to be burned and which is screened out. This is termed limestone screenings. It consists of both coarse and fine limestone rock. It is used to some extent as road material, but several Texas quarries have a quantity on hand which they sell for from fifty to seventy-five cents per ton in carload lots. This is probably the cheapest form in which to purchase lime for agricultural purposes. The agricultural value of the limestone screenings depends to some extent upon the quantity of fine material present. This will be discussed presently.

Ground limestone rock. Ground limestone rock is prepared from limestone screenings by grinding them finely, or it may be made directly from limestone rock. It costs more than limestone screenings, but, being more finely ground, is better suited to some purposes. It may be purchased in carload lots at the mills for about a dollar a ton.

Ground oyster shells. Oyster shells are rich in lime and can be used for agricultural purposes. They may be secured in quantity in some coast towns. They are a waste product from oyster shucking. They are not worth any more than ground limestone rock.

Marl deposits. In some parts of Texas there are deposits of carbonate of lime which are finely divided, like clay, or fall into a fine powder when exposed to the air. These deposits would be an excellent source of lime for agricultural purposes, as they require no grinding or other treatment. They could be loaded into the cars and hauled directly to the fields. Some of these deposits are not located favorably with respect to transportation facilities, but there are others which could no doubt be profitably developed in case the demand of lime for agricultural purposes in Texas assumes large proportions.

Some of the deposits of green sand marl in East Texas contain enough lime to justify their use, but most of these deposits contain so much iron and so little lime that their use at present cannot be advised.

Other sources of lime. Ashes, especially those from hard wood, contain lime, in addition to phosphoric acid and potash. Ashes should be saved and used for agricultural purposes as far as possible. Carbide waste, from acetylene gas generators, consists largely of lime. It should not be applied when fresh to land that is to be planted soon, as it may contain injurious substances. It is best exposed to the air three to six months before it is applied.

Decomposed shell may be found in some portions of the state near the gulf, and, if located within easy hauling distance, is a good source of lime.

CHEMICAL COMPOSITION

Table 1 shows chemical analyses of some samples of lime materials, made at this Station.

The relative values of the materials depend upon the quantities of lime present, and upon the character of materials. In a ground limestone, the portion which passes through a sixty-mesh screen should be considered as the most effective. The remainder will act more slowly and will be of some value, but the fine material is of more immediate value.

Roughly speaking, one ton of burned lime (stone lime) is equal to one and one-third tons of hydrated lime, or two tons of ground limestone.

HOW TO APPLY LIME

Finely divided lime materials may be applied by a grain drill or a lime spreader. Lime spreaders are sold by manufacturers of agricultural implements. Stone lime may be placed in piles on the ground, covered with earth, allowed to slake, and then spread, but this is not a very good method.

The best time to apply lime is probably after plowing. The lime should then be harrowed in, so that it is well mixed with the soil. The quantity to apply depends upon the object of the application and the nature of the soil. The amount varies from 500 pounds stone lime or more, or 1000 pounds of limestone rock, up to several tons of limestone rock per acre. Larger applications of limestone rock or marl may be made than of stone lime.

Farmers' Bulletin 921, entitled "Principles of the Liming of Soils," may be obtained free, from the Secretary of Agriculture, Washington, D. C.

LOCATION OF ACID SOILS IN TEXAS

Table 2 shows the distribution of acid soils in Texas. The acid soils found are located chiefly east of Matagorda, Colorado, Waller, Brazos, Robertson, Leon, Houston, Cherokee, Smith, Franklin, Dallas, and Red River Counties. West of this area a great many of the soils are rich in lime. This is particularly the case with the soils known as the black waxy soils, which are limestone soils.

Table 2.—Distribution of acid soils in Texas.

County	Surface soils total	Surface soils number acid	Subsoils total	Subsoils number acid
Anderson county	16	2	11	5
Angelina county	7	4	3	2
Aransas county	1	0	1	0
Archer county	10	0	10	0
Armstrong county	2	0	2	0
Atascosa county	6	1	5	1
Austin county	4	0	3	0
Bandera county	1	0	1	0
Bastrop county	11	2	8	1
Bell county	13	0	12	0
Bexar county	10	1	8	0
Bosque county	1	0	1	0
Bowie county	1	0	1	1
Brazoria county	20	2	16	2
Brazos county	62	7	59	13
Brown county	1	0	1	0
Calhoun county	6	1	5	1
Callahan county	1	0	2	1
Camp county	7	0	9	2
Cameron county	13	0	10	0
Cass county	5	2	5	2
Chambers county	2	2	2	2
Cherokee county	6	2	4	2
Childress county	2	0	3	0
Clay county	2	0	3	0
Collin county	1	0	1	0
Colorado county	11	4	9	4

Table 2.—Distribution of acid soils in Texas—continued.

County	Surface soil total	Surface soils number acid	Subsoil total	Subsoils number acid
Comanche county	4	0	5	1
Comal county	5	0	4	0
Coryell county	3	0	3	0
Crockett county	1	0	0	0
Dallas county	2	0	2	0
Dallam county	3	0	5	0
Delta county	7	2	5	0
Denton county	10	0	9	0
De Witt county	8	1	6	0
Dimmit county	9	0	1	0
Donley county	5	0	5	1
Duval county	4	0	2	0
Eastland county	13	0	10	0
Ellis county	15	0	15	0
Erath county	2	0	2	2
El Paso county	1	0	1	0
Fannin county	6	0	6	2
Fayette county	1	0	1	1
Floyd county	1	1	1	1
Fort Bend county	9	1	5	3
Franklin county	24	9	24	9
Freestone county	5	1	5	2
Frio county	2	0	1	0
Gaines county	2	0	1	0
Galveston county	6	0	1	0
Guadalupe county	2	0	0	0
Gillespie county	4	0	3	0
Glasscock county	1	0	1	0
Gonzales county	1	0	1	0
Goliad county	4	0	2	0
Grayson county	13	0	13	1
Gregg county	3	0	2	0
Grimes county	4	1	6	6
Hale county	1	0	0	0
Hansford county	2	0	1	0
Hardeman county	1	0	1	0
Harris county	22	5	17	1
Harrison county	31	20	25	21
Hays county	8	0	7	0
Henderson county	9	1	7	1
Hemphill county	1	0	1	0
Hildago county	2	0	0	0
Hill county	3	0	3	1
Hopkins county	4	1	4	2
Hood county	1	1	1	1
Houston county	8	2	6	2
Hunt county	1	1	1	0
Jack county	2	0	2	0
Jackson county	2	0	1	0
Jasper county	5	2	5	3
Jefferson county	19	10	18	8
Johnson county	1	0	1	1
Karnes county	2	0	2	0
Kaufman county	3	1	3	1
Kerr county	5	0	4	0
Kimball county	1	0	1	0
Knox county	1	0	0	0
Lamar county	7	0	5	4
Lavaca county	3	1	4	2
La Salle county	5	0	3	0
Lee county	8	1	6	0
Leon county	9	5	8	5
Liberty county	3	0	2	1
Limestone county	5	1	4	0
Lipscomb county	3	0	3	0
Live Oak county	1	0	0	0
Llano county	4	0	4	0
Lubbock county	22	0	21	0
Madison county	1	1	1	1
Mason county	5	0	3	0
Matagorda county	10	3	9	3
Medina county	5	0	6	0
Menard county	2	0	1	0
Mills county	1	0	1	0
Milam county	5	1	4	0
Mitchell county	1	0	1	0
Montgomery county	3	1	4	2

Table 2.—Distribution of acid soils in Texas—continued.

County	Surface soil total	Surface soils number acid	Subsoil total	Subsoils number acid
McLennan county	12	0	11	0
Nacogdoches county	4	0	1	0
Navarro county	2	0	1	1
Newton county	1	0	1	1
Nueces county	7	0	7	0
Ochiltree county	4	0	3	0
Orange county	7	2	3	2
Parker county	1	0	1	0
Parmer county	1	0	2	0
Palo Pinto county	3	1	3	0
Pecos county	1	0	3	0
Polk county	4	1	4	2
Potter county	1	0	1	0
Presidio county	1	0	1	0
Randall county	2	0	1	0
Red River county	6	2	6	3
Reeves county	4	0	3	0
Refugio county	4	1	1	0
Robertson county	23	5	16	3
Rusk county	5	0	4	1
Runnels county	2	0	1	1
Sabine county	2	2	2	2
San Jacinto county	2	1	1	1
San Saba county	36	1	37	1
San Patricio county	1	1	1	0
Smith county	25	8	22	13
Sutton county	6	0	6	0
Swisher county	2	0	2	0
Tarrant county	2	0	1	0
Taylor county	46	1	44	0
Titus county	14	2	13	5
Tom Green county	1	0	2	0
Travis county	5	0	6	0
Trinity county	2	2	2	2
Tyler county	5	5	3	3
Upshur county	2	0	2	1
Uvalde county	5	0	5	0
Val Verde county	6	0	3	0
Van Zandt county	2	0	3	1
Victoria county	5	0	4	1
Walker county	4	2	4	2
Waller county	6	3	5	2
Washington county	2	0	2	0
Webb county	26	0	16	0
Wharton county	2	0	3	0
Wilbarger county	1	0	1	0
Williamson county	1	0	0	0
Wilson county	16	2	13	1
Wise county	2	0	2	0
Wood county	5	1	6	4
Zavalla county	6	0	6	0

As an example of the distribution of the acid soils, we find that four out of seven of the surface soils of Angelina County are acid, and seven out of sixty-two surface soils of Brazos County. In Franklin County, nine out of twenty-four samples were acid, while in Harris County five out of twenty-two. In Harrison County, twenty out of thirty-one were acid, and in Houston County, two out of eight. In Robertson County, five out of twenty-three were acid; in Smith County, eight out of twenty-five; in Titus County, two out of fourteen; in Tyler County, five out of five, and in Waller County, three out of six. The number of samples examined in some counties is not sufficient to show the distribution of acid soils in the counties.

On the other hand, no acid soils are found in Archer County, Bell County, Cameron County, Camp County, Comal County, Denton County, Grayson County, Lubbock County, McLennan County, Webb County, and many other counties which are named in the table. In other counties a very small proportion of acid soils were found.

Table 3 contains a list of acid soils found in a number of Texas counties. The list does not include all of the acid soils found in Texas. The table shows the soil types which are acid, and the degree of acidity found to exist in them.

The acidity is expressed in parts per million of lime required to neutralize it. The soils are assumed to weigh two million pounds to the depth of seven inches, and this amount is required for the surface seven inches. Thus the soil with an acidity of 400 parts per million would require 800 pounds of lime per acre to neutralize it. This means lime in a chemical sense. Since limestone rock contains about fifty per cent lime, it would require about 1600 pounds of limestone rock per acre, finely ground, to neutralize 400 parts per million of acidity to a depth of seven inches.

Table 3.—Acid surface soils.

Lab. No.	Description	Acidity
	Angelina County:—	
1283	Norfolk fine sandy loam	200
895	Lufkin fine sand	300
11287	Homer, Texas	700
12974	Homer	460
	Brazos County:—	
4229	Experiment Station soil	300
6953	Bryan	200
6955	Bryan	200
8341	Norfolk sand	460
8343	Lufkin clay loam	230
8375	Crockett silt loam	230
12667	Crockett loam	1100
	Cass County:—	
7112	Atlanta	600
7239	Hughes Springs	200
	Chambers County:—	
6680	Glens, Texas	800
14204	Smith Point	1100
	Cherokee County:—	
4342	Rusk	200
4601	Jacksonville	300
	Colorado County:—	
3248	Prairie Land	200
6268	Rock Island	200
7244	Rock Island	200
	Delta County:—	
8838	Upland	230
D817	Lufkin fine sandy loam	145
D893	Lufkin clay	500
	Franklin County:—	
1133	Norfolk fine sand	200
1139	Norfolk fine sandy loam	200
1314	Lufkin silt loam	1000
1318	Caddo fine sandy loam	200
1324	Lufkin fine sandy loam	300
1326	Franklin clay	300
1121	Hogensport loam	800
1129	Lufkin silt loam	2700
8836	Lufkin fine sandy loam	460

Table 3.—Acid surface soils—continued.

Lab. No.	Description	Acidity
	Harris County:—	
8119	Katy	200
9440	Cypress	460
9441	Cypress	230
9273	Addicks	230
9305	Humble, Harrison county	230
4721	Norfolk fine sandy loam	200
4725	Susquehanna fine sandy loam	200
4701	Lufkin silt loam	1000
4703	Sanders silty clay	2800
4707	Kalmia fine sand	300
4709	Kalmia fine sandy loam	300
4713	Susquehanna very fine sand	700
4715	Orangeburg fine sand	300
4719	Orangeburg fine sandy loam	300
6202	Caddo fine sandy loam	200
6205	Sanders silt loam	600
6206	Orangeburg sandy loam	300
6208	Kalmia sand	200
6216	Susquehanna gravelly sandy loam	200
6218	Susquehanna fine sand	600
7994	Susquehanna fine sand	200
6194	Susquehanna clay	200
6217	Susquehanna gravelly sandy loam	500
6220	Susquehanna sandy loam	1400
	Houston County:—	
314	Norfolk fine sand, 0-10	200
320	Lufkin clay	500
	Jasper County:—	
9163	Kirbyville	900
9165	Kirbyville	700
	Jefferson County:—	
4215	Beaumont	300
4644	Sandy upland, 0-8	300
137	Rice soil, Beaumont	113
7183	Arcadia clay	1400
7185	Lake Charles silty clay loam	200
890	Sandy loam soil	200
7194	Lake Charles clay	600
7198	Arcadia very fine sandy loam	400
7202	Crawley clay 0-8	600
7219	Lake Charles very fine sandy loam	600
	Leon County:—	
4646	Sandy upland surface soil	200
4650	Red sandy soil	300
4308	Poor upland	200
4585	Soil spot	200
7108	Flynn	230
	Matagorda County:—	
7116	Dark gray soil	462
9352	Surface soil	460
11304	Bay City	230
	Orange County:—	
7695	Soil near Mound	2000
7696	Soil from Mound	400
	Red River County:—	
3403	Moderate upland	200
4583	Upland	300
	Robertson County:—	
818	Sanders loam	145
843	Wabash clay	300
3008	Wabash clay	200
819	Norfolk fine sandy loam	70
	Sabine County:—	
10958	Riverland	1100
10960	Surface soil	700
	Smith County:—	
4642	Upland	300
9275	Soil	230

Table 3.—Acid surface soils—continued.

Lab. No.	Description.	Acidity
	Smith County—Continued.	
9867	Orangeburg fine sandy loam	230
9871	Ocklocknee clay	2100
9977	Surface Ocklocknee silty clay loam	1100
9700	Ballard	1100
9708	Ballard	230
9975	Kalmia fine sand	230
	Titus County:—	
2346	Susquehanna gravelly loam	200
2350	Susquehanna fine sandy loam	200
	Trinity County:—	
4370	Pennington	300
4597	Light sandy loam 6″	200
	Tyler County:—	
3976	Lufkin clay	1000
3977	Norfolk sandy loam	200
4648	Woodville	200
9139	Surface soil	460
10614	Spurger	460
	Walker County:—	
6881	Huntsville	100
6886	Camp Goree State Farm	300
	Waller County:—	
9357	Surface soil	460
7237	Brookshire	200
11228	Surface soil	460
	Wilson County:—	
850	Webb fine sandy loam	500
859	Norfolk fine sand	200

An examination of the table shows that the acidity of Texas soils is in general quite low. Most of the soils shown in the table have an acidity of from 200 to 400 parts per million. The acidity in the surface seven inches would be easily neutralized by an application of 1000 pounds of limestone rock.

There are nine soils in the table that have an acidity of from 1100 to 1400 parts per million. This would require about two tons per acre of limestone rock to neutralize the surface seven inches. There are three soils shown in the table having an acidity of from 2000 to 2800 parts per million. This acidity would require from four to six tons per acre of limestone rock to neutralize.

Acid soils are not so widely distributed in Texas as they are in many of the northern states, and the degree of acidity is in most cases less. The use of lime or limestone is not generally needed in Texas for the purpose of correcting acidity, although it is needed for some soils.

USE OF LIME ON TEXAS SOILS

Taking into consideration the foregoing facts, the following recommendations are made with respect to the use of lime on Texas soils.

Lime or limestone should not be used generally on Texas soils, but only on such soils as are known to need lime, or for certain special purposes.

Lime may be applied with advantage to sticky clay soils in the sec tion east of the black lands of Central Texas for the purpose of rendering the soil more easily cultivated, and in some cases for the purpose of correcting acidity. The lime should be applied at the rate of from one to four tons per acre of ground limestone screenings or ground limestone. The black waxy soils, and many of the other soils of West and Central Texas are rich in lime and there is no advantage whatever in making further additions.

Lime should be applied to the soils of East Texas at the rate of from one to two tons per acre of limestone screenings, when alfalfa is to be grown. The addition of lime to light sandy soils is not advised. Lime is usually not needed for alfalfa on the soils of West or Central Texas. Lime may be applied to loams and clays of East Texas, excepting black lands, for the purpose of growing peanuts, at the rate of from 100 to 2000 pounds per acre, or more, if the acidity of the soil needs more for its correction. The application of lime on light sandy soils is not suggested. The Spanish peanut does not seem to require lime as much as does the large Virginia peanut.

Lime should be applied to the loams, clays and clay loams of East Texas and the gulf coast section which experiments have shown to be acid. The chemist of the Texas Experiment Station will test samples for acidity free of charge. As a rule, 1000 pounds per acre of limestone screenings is sufficient.

The use of lime on light sandy soils easily penetrated by water is likely to cause a loss of fertility due to plant food being washed out. Lime should be used on such soils only when a cover crop is grown during the winter, and some crops are kept growing practically all the year round. The growing crops will take up the plant food and prevent it from escaping in the winter.

The best results with lime will be secured in a proper rotation of crops, including a legume to be turned under or grazed off for the purpose of obtaining nitrogen from the air, or the application of large quantities of barnyard manure to take the place of the green manure crops. The use of a winter cover crop is also advisable, for the purpose of preventing the loss of plant food during the winter months.

SUMMARY AND CONCLUSIONS

Lime is not regarded as a fertilizer, but it is possible that some soils do not supply enough lime for some crops, such as alfalfa.

Sticky clay soils which are worked with difficulty are often improved by additions of lime. The black waxy soils of Central Texas are rich in lime.

The addition of lime may render phosphoric acid more available on some soils. On soils low in total phosphoric acid this would be only of temporary advantage.

Lime causes the soil nitrogen to change into nitrates more rapidly, and these are easily taken up by plants and also easily washed out from the soil. The use of lime on sandy soils may cause a quantity of nitrogen to be washed out and lost.

The acidity of soils is due to a variety of causes. In some soils acidity may be more injurious to plants than in other cases when the same degree of acidity is due to less injurious causes.

Alfalfa, barley, oats, peanuts, and many other crops are benefited by additions of lime to acid soils. Irish potatoes, cowpeas, watermelons, and a few other crops are injured by an application of lime to an acid soil.

Lime may be secured in the form of stone lime, hydrated lime, limestone screenings, ground limestone rock, ground oyster shell, and limestone deposits. At the present time, the cheapest form and the one most easily secured is limestone screenings.

The acid soils found in Texas are located chiefly in East Texas, and in the gulf coast section east of Matagorda County. A table is given showing the relative abundance of acid soils in the various counties. In the central and western parts of the state there are few acid soils, and many other soils are rich in lime.

The acidity of Texas soils which are acid is generally low.

Lime or limestone should not generally be used on Texas soils, but only on such soils as are known to need lime for special purposes.

Lime may be applied with advantage to many sticky clay soils in the gulf coast section and in East Texas, for the purpose of making the soil more easily cultivated.

Lime should be applied to the soils of East Texas or the gulf coast section if an attempt is made to raise alfalfa.

Lime should be applied to the loams, clays, and clay loams of East Texas and the gulf coast section which experiments have shown to be acid.

The use of lime on light sandy soils easily penetrated by water is not generally advised, on account of the loss of fertility which may take place from nitrogen being washed out.

The best results with lime should be secured in a rotation of crops, including a legume to be turned under or grazed off for the purpose of securing nitrogen from the air.